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THE MODERN HOSPITAL AND MEDICAL PROGRESS[1]

To have the privilege of bringing to you the congratulations of my associates of the Rockefeller Institute on this, the one hundredth anniversary of the founding of the New Haven Hospital, is at once a great honor and a privilege.

This hospital began as a local organization to care for the sick and suffering poor of the community. We have learned how, from time to time, it has widened its field of activities and increased the breadth of its functions. In doing this it has emerged from its state of provincialism and has become truly cosmopolitan. It no longer ministers only to a small proportion of the inhabitants of a relatively small city, it no longer dispenses its beneficence only to those who enter its portals as patients, but it brings aid to the sick and suffering and protects the well in distant lands. Its influence reaches wherever scientific medicine is practiced. This widening of influence is due to a large extent to the inclusion of *education* and *research* into the formula of its functions. In assuming these new obligations this hospital has but reflected the great change which is everywhere taking place in the conception of the proper activities and duties of a hospital.

The idea of hospitals originating in man's feeling of sympathy and compassion for his fellows in distress, an emotion which very rarely is entirely lacking, even in the most rude and ignorant savage. This spirit of compassion led to the care of the sick and distressed when they are without home and friends. At first this could be done in the protector's household, but hospitality to such an extent, always difficult and burdensome, must have been almost impossible under primitive conditions. The Greeks organized institutions, *Xenodochia,* to which slaves could be sent when they were ill or were too feeble to work. The Arabs also organized institutions for caring for the ill, the most renowned one, built in Cairo in the thirteenth century, provided accommodations rivalling those of the hospitals of to-day. It was the coming of the Christian religion, however, with its deep content of the spirit of brotherly love, that stimulated the build-

[1] Address delivered at the New Haven Hospital, May 27, 1926, on the occasion of the celebration of the One Hundredth Anniversary of the Incorporation of the General Hospital Society of Connecticut.

ing of places in which the sick could be cared for. Especially the institution of the religious orders and the organization of the monasteries gave the greatest impetus to the development of hospitals.

The oldest existing hospital in London, St. Bartholomew's, recently celebrated its eight hundredth anniversary. It was founded by Rahere, a monk, who, having led a sinful life, made a journey to Rome, hoping by so arduous an undertaking to obtain forgiveness of his sins. While at Rome he fell ill and thought his last hour was drawing nigh. He then vowed a vow that, if he were allowed to return to his own country, he would build a hospital for the care of the poor. This was typical of the foundation of the hospitals of the middle ages. Their establishment was prompted by a spirit of pity or was undertaken as a penance for sin.

Although there were some exceptions, the relationship of these institutions to the development of medicine was not important. To all intents and purposes they were almshouses for the sick. There were no resident physicians. The remedial measures employed, when they were not harmful, were simple ones, magical words, nauseous mixtures, prayers, herbs, or the bark of trees. Norman Moore, in his history of St. Bartholomew's Hospital, has described one of the physicians in the following words:

> He employed a great variety of drugs, the reputation of which did not rest on experiment. He was not inattentive to the details of nursing. . . . He was equal to the physicians of our own time in his consideration for the feelings of his patients, in his desire to alleviate suffering and in his eagerness to master all the learning of his time. He was their inferior in method of observation as well as in every part of science.

At this time the most superficial aspects of disease were recognized. Men sickened and died, but knowledge concerning the nature of disease was almost entirely lacking; in what particular the sick differed from the well was not investigated. What the Greeks had learned of biology had been forgotten. As in all ages, even the present, man was more interested in the other manifestations of nature than in himself. Man knew the course of the stars in the firmament long before he had any idea of the vital activities of his own body. As he knew little about his body in health, he, of course, knew less about the conditions when unusual deviations in his physical state, that is, illness, occurred. I have recalled these facts to your mind only to emphasize the origin of the hospital idea, how interwoven it was with the idea of alms giving, how limited and provincial it was in its outlook, how unconcerned it was with the nature of disease. This conception of the hospital as providing chiefly, if not entirely, for the material and spiritual comfort of the poor when they are ill has persisted up to the present and has been difficult to dislodge from the minds of men.

As you all know, in the fifteenth and sixteenth centuries came the great revolution in man's mode of thinking. You are all familiar with this as it affected intellectual and artistic activities, as it influenced scientific development. Probably you have thought less about it in its relation to medicine. In the sixteenth century man came to see how he was made. He now saw the inner structure of his body clearly, with his own eyes, and not dimly, as before, through a haze of authority and tradition. This was important, but it was not nearly so important, even for medicine, as the fact that men in all affairs began to demand proofs. Concepts and theories alone no longer were satisfying. Every truth must be established by actual demonstration. Thus was ushered in the age of experiment, the full significance of which we are now only beginning to realize. At once the science of physics began to emerge and the science of chemistry to develop. Although the movement had relatively less influence on biology, nevertheless activity was now stimulated in ferreting out the secrets of life, in attempting to disclose the true nature of pathological processes and in endeavoring to devise means for delaying the progress of disease and overcoming its effects. Medicine began to be an objective and an experimental science. Physicians became scientists.

All this inevitably influenced the character of the hospitals. They became more closely linked with medicine. They began to have less the character of almshouses and to become institutions to which the sick were admitted in order that they might be relieved of the effects of disease. The hospitals also began to take part in the promulgation of the new knowledge concerning disease and its cure. They tended to become a part of the mechanism for instructing physicians. They added the function of education to their purely charitable aims. The idea that "a hospital is the laboratory where the results of Nature's experiments are to be studied and alleviated by the methods of science" began to be accepted. This step was taken only gradually, however. At first it was argued that the hospitals were institutions for the sick, not organizations for the instruction of physicians. It took centuries to overcome this prejudice and only recently the idea that the education of physicians is a legitimate function of the hospital has been generally accepted.

The education of physicians to-day is a far more complex matter than it was three centuries ago. The introduction of the experimental method into science

and the development of physics, chemistry and biology, were followed by an amalgamation of the content and principles of these sciences into medicine, so that medicine itself tended to become an exact science. As a result of this the course of instruction for the medical student has become so complex that, to the uninitiated, it seems bewildering. The student to-day must not only learn all the essential facts which have been developed in chemistry, physics and biology during the past centuries, but he must also learn how to apply this knowledge in his attempt to understand the phenomena occurring in the sick individual. It is no longer sufficient to name the disease from which the patient suffers and prescribe an appropriate remedy. The physician of to-day must attempt to analyze the disturbances accurately. He must be prepared to measure the alterations manifesting themselves from day to day, and his treatment must be established on a quantitative basis. Complicated instruments have been devised for the physician to use in making these measurements. Some years ago, Dr. Weir Mitchell wrote a most interesting paper on the early history of instrumental precision in medicine. He tells how three centuries before "the unerring regularity of the swinging of a suspended lamp in the cathedral of Pisa suggested to the young medical student, Galileo, the reverse idea of marking with his pendulum the rate and variation of the pulse." With such slowness, however, did the ideas of precision and accuracy make their way into medical practice, that it was only under the influence of the great Dublin school, in the first half of the last century, "that the familiar figure of the doctor, watch in hand, came to be commonplace." The procedure of counting the respirations came to be customary even later. Laennec, the inventor of the stethoscope, who only died in 1826, "never mentions, in seven hundred pages of his writings, any enumeration of breathing." The introduction of the clinical thermometer required even a longer time, although crude thermometers for measuring the heat of the body were constructed early in the seventeenth century. It was two centuries later before the thermometer came to be recognized as of value in the physician's armamentarium. I have heard that only one or two of the military surgeons of our Civil War employed a clinical thermometer. These men were probably looked upon as ultra-scientific and therefore impractical. In 1868, however, Wunderliche's classic work on clinical thermometry appeared and this finally convinced the medical world of the importance of the thermometer in medicine.

Nothing brings a more startling realization of the changes that have taken place in medical practice within the past few years than to read this paper of Mitchell's in the light of the present situation as regards quantitative methods in clinical examinations. What would be the opinion of the laymen of to-day if the physician failed to record the temperature of the body, and in case the disease is of any duration, to measure it frequently and to record the results in the form of a curve, so that the variations may be readily interpreted? What would be thought if he failed to determine accurately the pulse and respiration rates at equally frequent intervals, or if he neglected to count the number of corpuscles in a cubic millimeter of blood, or to measure the blood pressure in millimeters of mercury, a method so recent that it was introduced by one of my classmates? How shocked the physicians of any hamlet would be if one of their colleagues failed to determine the number of leucocytes per cubic millimeter of blood in the patient suspected to have appendicitis. All these methods of accuracy which I have mentioned are to-day among the most rudimentary and simple procedures in medicine. The modern physician must have accurate knowledge of the exact rate at which chemical changes are going on in the body, the so-called metabolic rate. He even must have records portraying electrical changes initiated by the heart at each beat. He demands accurate quantitative chemical analyses of the blood and the excreta. In addition to all these measurements, of which I have mentioned only a few, he must be skilled so that, by means of the stethoscope, he can hear and interpret the meaning of noises and musical sounds caused by the air passing in and out of the lungs, and those produced by the blood passing through the various chambers of the heart. He must be prepared to extend his vision to our innermost recesses by means of tubes and lights. He must even look through our solid tissues by means of X-rays. If we are infected with a bacterium, be it so small that it can only be seen with glasses of the highest magnification known, he must be prepared to determine its exact nature. And with all these instruments and procedures he must be familiar, not only as technical methods, if he is to use them successfully, but he must also know the scientific principles underlying their construction and use, otherwise they are but gewgaws to catch the unwary. Is it a wonder that medical education to-day requires the expenditure of long time and much money? So far as the instruction of the student in the basic sciences is concerned, so far as it is a matter of the study of the structure of the body, that is, anatomy, so far as it is a question of acquiring knowledge of biological phenomena, physiology or even of learning about the *methods* employed in the investigation of disease, the hospital is superfluous and unnecessary. Education and training in these things is the work of the university. But when the student has mastered all these he is not a

physician. He must study disease as it occurs in human beings. He must know how to apply in this study all the information that he has previously acquired, otherwise all his learning, all his skill in technique will profit him nothing when he comes actually to diagnose and treat, and, if possible, cure, our illnesses.

The details of instruction do not press hardly on the authorities in control of this hospital and on those of like situation. Here in the shadow of a great university and with the hospital virtually a component part of the university, the machinery of education is at hand, and the hospital authorities can easily obtain assistance in meeting their obligations. But the opportunities for wider service in the educational field are not confined to those hospitals so fortunately situated as is yours. The opportunity is open to every hospital in this country to share in the development of scientific medicine and thereby to multiply its services to the community which it serves.

In this country the medical student enters the medical school with some knowledge of physics, chemistry and biology. He then spends four years in a medical school and during this time he is expected to learn thoroughly the anatomy of the human body; he must also learn as much as possible about the functional activities of the body in health, he must learn about the nature of disease, the various causes, the structural and functional alterations that accompany, and result from disease. He must learn about the nature of the remedies that have been discovered and how they act. Then he must master the technique of studying disease, the methods employed in diagnosis, some of which I have mentioned. Now how much time is there left to become familiar with all the multitudinous manifestations of disease as it actually occurs? Fortunately, in schools, such as this, he may be able actually to work in the wards with the patients, but only for a few months, not long enough to make him a physician. Medicine should be as scientific as the state of science permits, but this does not mean that this discipline consists merely of a group of underlying principles which, once mastered, give the clue how to act in every emergency. Experience and training are essential for the physician. That the student does not and can not receive this training during the four years in the medical school is recognized both by the students and the faculty. That the students recognize it is shown by the fact that almost every graduate seeks to obtain a post as interne in some hospital. Here he remains for one or two years, or even longer. These years which he spends in the hospital as an interne should be the most profitable years in the education of the young physician. During these years he forms the habits which he follows during his entire professional career. During this period he either continues to be a student of disease and becomes a capable physician, or he is satisfied with what he has learned in the medical school, his intellectual growth stops and he becomes merely a routine practitioner and a man of business.

In not very remote times the young man on deciding to become a physician picked out the best doctor in the community to act as his preceptor and he placed himself under his direction. He went about with the older doctor, seeing his patients and learning from him the technique of practice. In addition he picked up many scraps of worldly wisdom and had transmitted to him the high ethical principles which for ages have been practised by the members of the medical profession. I have no doubt that there were good and bad preceptors, but the method, as a method, has much to be commended. Such a system now would be impossible, but the hospitals of to-day have the opportunity to replace in large measure the best of the preceptor system. By taking advantage of this opportunity every hospital in this country, even the smallest hospital in the most remote district, can share in the educational work which is able to extend so greatly the hospital's influence and effectiveness.

Unfortunately, at present, the interne is often regarded, and he regards himself as a fully trained physician. He fails to realize that he is still a fledgling and still requires vigorous training. Too often the hospital authorities and also, alas, the physicians of the hospital fail to realize their opportunities and obligations for directing him and for providing him with the means for obtaining the training which he needs. In my contact with young physicians, some of them from the best hospitals, I have been disturbed to learn how little they have received in the way of training, and how little they have developed intellectually, during their interne years. Only too often they have spent their days in routine occupations and have occupied their evenings in play or useless reading. They have not practised the scientific procedures about which they learned in the university. These have been performed in the hospitals by hired technicians. This is not the place to discuss the remedies for this state of affairs, but I may venture to offer certain suggestions.

The hospital authorities might, at least, provide a working library and, so far as possible, stimulate the internes to read good scientific and medical literature. It would be of very great advantage if each interne could be provided with a small laboratory which he can use as he pleases. Here he can acquire the habit of observing with his own eyes and making tests with his own hands, not in any routine way, but to satisfy his own curiosity. His laboratory

should be in miniature the laboratory which every scientific physician should have in connection with his examining room. Some internes will be interested in employing simple chemical methods, others will be more interested in employing the technique of bacteriology. All should have a microscope and should use it frequently.

The stimulation of an interest in the historical and literary aspects of medicine should not be neglected. It is important for the hospital to cultivate men as well as scientists. It would not involve great trouble or expense to place in the living quarters of the internes pictures of the great masters of the past and a few of the books of great physicians who have also roamed in the pleasant fields of arts and letters.

The hospital having provided the means for scientific culture, the stimulus to make use of them must come from the physicians who are responsible for the medical work of the hospital. In recent years practising physicians have at times complained that they are being deprived of the opportunity to teach. It is true that they have less opportunity now than formerly to share in the scientific education of medical students during the university period. But they have an extraordinary opportunity to influence the students during the interne years, during the period when they are studying the various manifestations of disease, during the period when they are learning how to practice medicine. The cultivation of the relationship of preceptor and pupil between the hospital physician and interne may go far in removing the danger that medicine may become too highly organized, or that the methods of the factory be applied in the treatment of disease. The physician's responsibility toward the interne should not end when he sees that the routine records are kept in a fairly orderly fashion. He may be counsellor, guide and friend, and through proper direction he may aid in making of the interne a student of disease, a scientific physician, a well-trained practitioner and a true gentleman.

The statement that "the true test of national medical progress is what the country physician is" contains more than a germ of truth, and the duty rests on the hospitals of the country and on the physicians of these hospitals to see that the country doctor, even though scientifically trained, is not a poor practitioner. The duties and the work of the hospital to-day are identical with those of the physician of yesterday, and the rôle of the preceptor of bygone days must be assumed by the modern hospital.

Time changes, but the ambitions, the methods and the work of the physician, as Osler described them, must not be altered:

> To wrest from nature the secrets which have perplexed philosophers in all ages, to track to their sources the cause of disease, to correlate the vast stores of knowledge, that they may be quickly available for the prevention and cure of disease—these are our ambitions. To carefully observe the phenomena of life in all its phases, normal and perverted, to make perfect the most difficult of all the arts, the art of observation, to call to aid the science of experimentation, to cultivate the reasoning faculty, so as to be able to know the true from the false—these are our methods. To prevent disease, to relieve suffering and to heal the sick—this is our work.

In addition to the function of teaching, the modern hospital has assumed another function, that of research, of endeavoring to contribute to knowledge concerning disease. In this also all hospitals can share, although the most important results are likely to come chiefly from hospitals like yours connected with medical schools, where organized research can be undertaken. Just as hospitals were loath to accept their opportunities in the field of education so have they hesitated to undertake and support the investigation of disease. In this they have again failed to realize the returns which may accrue to the hospital in the way of increased prestige and wider service. A hospital in which a new discovery is made at once becomes no longer a local institution. There occurs immediately an increase of its reputation and fame. There results an extension of the good it accomplishes. It now serves all mankind.

The merchant, Johns Hopkins, of Baltimore, was a wise man. What more lasting monument could he have erected than that which he built when he established a hospital in which education and research were to be important functions. Suppose he should have left his money for the establishment of a hospital merely to care for the poor of Baltimore? Most of us would never have heard of Johns Hopkins. As it is, there is not an educated person in this country who does not know of this hospital and is not familiar with the donor's name. The poor of Baltimore have received far better care than would have been the case if education and research had been omitted and not only Baltimore, but the entire world, has been made much richer and better.

I, myself, happen to be connected with a hospital, the first function of which is research. This does not mean that patients entering the hospital and placing their lives in the custody of the physicians do not receive the very best care that it is possible to give or that everything possible is not done, or that anything is left undone, to restore them to health at the very earliest moment. Research in medicine is not antagonistic to the highest humanitarian motives or to the best medical treatment; quite the reverse. Contrary to certain apprehensions, expressed at the time of the opening of the hospital, the number of patients has never been limited because people were afraid to come, fearing that they would be experimented upon. Pa-

tients request admission to such a hospital because they recognize that if the desire to learn activates the physicians, all that is possible will be learned, and increased knowledge gives increased power to help.

While most of us agree that research in medicine is important, we probably do not all agree concerning the part which the hospital should play, or is able to play, in this endeavor. It is true that in research concerning disease much can be learned, and in the past has been learned, through experimental studies carried out in laboratories not immediately connected with the hospital. It seems obvious, however, that no study of any disease can be complete without the direct observation and investigation of patients suffering from this disease. It is in these patients only that the phenomena that it is desired to study can be seen. Moreover, the superficial aspects of these phenomena, at least, can only be investigated by those who are trained in clinical medicine. Much has, and still can be, learned by employing clinical methods alone and the importance of such studies is not to be undervalued. But it would seem unwise to restrict the clinician to the employment of these simple methods. To limit any serious investigator to the most simple aspects of his problem would only result in destroying his interest and extinguishing his enthusiasm. It is felt, therefore, that the hospital should offer opportunities to students of clinical medicine to carry on investigations of disease, even though these investigations may require the employment of the most complicated laboratory equipment and the application of the most fundamental methods of the basic sciences.

The physician coming in daily contact with the sick has a constant appeal made to him to search for facts which may result in methods of relief. It is not intimated that the laboratory worker does not also feel this humanitarian impulse, but the physician, having the results of disease constantly before him, is more likely to keep his mind on the real purpose of the investigation and therefore is not likely to wander far away from the main problem. On the other hand, there are many workers who should experience no restraint of any kind in their investigations. They are the men from whom probably the most can be expected in unravelling the riddles of disease, and it will be a sad day for science and for progress when these men are not given full liberty. These men, however, should work in the laboratory. While the methods employed by the workers in the hospital and those in the laboratory may frequently be identical and their fields of work may frequently overlap, this is not to be deplored or to be avoided. The problems are large enough, the ends sought are important enough, to justify an attack by many men with different points of view and different kinds of training. There is no great danger that investigations by physicians in the hospitals will become too involved, too fundamental. It is fortunate for medicine if physicians can be found who are sufficiently well trained and have sufficient intellectual equipment to enable them to attack the problems of disease with the most complicated methods of the exact sciences.

In the past physicians caring for the sick have played an important part in the progress of science, not only in biology but also in physics and chemistry, even in astronomy. Copernicus was a physician; Gilbert, one of the most important figures in the history of electricity, was physician to Queen Elizabeth; Paracelsus, the father of chemistry, was a doctor; Robert Mayer, who demonstrated the principle of conservation of energy, was a country doctor. The list might be extended indefinitely. Indeed, in the development of pure science, up to very recent years, physicians played a leading part and they constituted a considerable proportion of the membership of the learned scientific societies. The results of their own labors, however, ultimately excluded them from participation in scientific pursuits. As medicine became more technical and intricate, the demands on the time of the practitioners became greater and greater, so that finally physicians found time only to apply the results of the labors of their former colleagues and were compelled to commit the advancement in science, including medicine, largely into the hands of their laboratory confrères.

Fortunately, in very recent years there has been an attempt to remedy this situation. It has become obvious that the services of the clinician, with his knowledge of disease as it occurs in man, should also be employed in organized and intensive research concerning its nature. In order to permit this, however, it is necessary that these physicians have protection and relief from an excess of routine duties, and above all that they be relieved of the exactions of private practice. Certain hospitals, like this one, have not delayed in providing these conditions and the results are already justifying this program.

The complicated investigation now carried on in the hospitals can rarely be made by one man working alone. They usually require the cooperation of a number of men and they require the use of many complicated methods of the exact sciences, and of many sensitive instruments, which, in comparison with the instruments of precision mentioned by Mitchell, are as the delicate tools of the watchmaker to the broad axe and saw of the woodsman. In a recent book, two famous experiments have been contrasted, the first one being devised by Galileo at the outset of his career, and the other by Michelson, with the aid of his famous interferometer, carried out in 1891 and

repeated in 1905. Galileo dropped heavy balls from the top of the leaning tower of Pisa and demonstrated that objects of different weights, if released simultaneously, reach the earth together. So far as experimental skill and delicacy of apparatus were concerned this experiment could have been made at any time within the preceding five thousand years. Michelson's experiment could not have been made a day sooner than it was. This experiment concerned the determination of the earth's motion through the ether and has an important bearing on the theory of relativity. It required the general advance in technology, and was conditioned upon the state of scientific knowledge then existing.

Now, in the study of disease, a stage almost corresponding to that of Michelson's experiment has been reached. Edward Jenner, somewhat over a century ago, through the simple observation that dairy maids, after infection with the cowpox, failed to contract smallpox when later they were exposed to that disease, deduced the theory that inoculation with virus from infected cows would protect inoculated persons from contracting the more severe human disease. This great discovery was not dependent in any way upon the state of the basic sciences. It might have been made by the Greeks if the conditions had been propitious. Discoveries like this will always be made. Simple experiments, like that of Galileo, may even now yield information of the first rank, even in physics. In the discovery of new facts about disease, however, the path to be trod at the present time is usually more intricate and is as dependent upon the basic sciences as was the famous experiment of Michelson.

Let us consider for a moment an investigation which is now under way in your hospital and elsewhere. This investigation has to do with the disease in children known as rickets. Something over two centuries have passed since the classic account of this disease was given by Glisson (1650). In the succeeding years much was learned about this disease through simple observation—the conditions under which it appeared, its frequency in different places, and so forth. Then came a period during which the finer microscopic changes in the bones and other structures of the body were detected and described. But when all this was accomplished the real nature of the condition was almost as obscure as it had been two centuries before. It now becomes necessary to investigate this problem with all the aids which modern chemistry and modern physics can supply, if the real secrets of the disease are to be revealed. It is true that chance observations have accelerated progress just as they so frequently do in all scientific investigations. No chemical studies were needed to learn that codliver oil is of value in the treatment of this disease, or that exposure to sunlight is in some way important in its prevention. But it is hardly possible that chance observations will give the answer as to why these measures have an effect and still less tell us what the essential nature of the process, which we designate as rickets, really is. In any case, modern man is not content to wait for chance observations to give him information. To-day we explore. We do not wait for the wrecked mariner to return home to tell us of unknown lands.

The complete solution of the problem of rickets requires that information be obtained concerning the physical state of calcium in the blood and the conditions under which it is deposited in the bones; inasmuch as the main feature of the disease, the bending of the bones, is the result of a failure of calcium deposition. A few years ago we might have thought that the problem could be solved by simple chemical estimation of the inorganic calcium in the blood and tissues, but we now know that such information alone adds but little. It is necessary to know not only the actual amount of calcium present but also the physical state in which it exists. This requires the methods of physical chemistry. Fortunately, this science, due largely to the genius of one of your greatest men, Willard Gibbs, has developed so far that it is not impossible that the physical conditions existing in the blood, that most complicated of all fluids, will soon be made simple and understandable. Then it seems that light, which, as we know, in some mysterious way touches the chlorophyl in the plants so that the leaves burst forth and the plant grows, is also concerned in the deposit of calcium in the bones. To investigate this requires making use of the methods and content of one of the most complex branches of physics. To one standing afar off the difficulties seem too great to be overcome. It would seem absurd to attempt to solve such riddles. Yet, the methods are available; the men are ready, and indeed are at work in a half dozen clinics and laboratories. It would not be surprising if any day we should be told what the nature of rickets really is.

There are many such problems waiting for solution to-day and their solution will bring relief to thousands of sufferers and happiness to thousands of households. We are apt to boast of the enormous progress that has been made in medicine during recent years. These discoveries have produced an effect on mortality statistics and on the average length of life that is most gratifying. But if we contemplate the history of physics and chemistry during the past three hundred years and consider how biology has delayed in making use of the methods that have been so fruitful in the other sciences, one wonders whether, after all, medicine to-day may not be in about the same

stage of its development that applied physics was in the middle of the last century when, although the principles underlying the telegraph and telephone had been developed, the real wonders of our age, such as radium and the wireless transmission of the voice and sound, had not even been imagined. With the present rapid application of the recent great discoveries of physics and chemistry to the solution of problems of disease and other biological phenomena, it is not impossible that the next decades will witness discoveries relating to the prevention and cure of disease which will far transcend the discoveries of the past half century.

Is it not stimulating to us who are interested in hospitals as instruments for the furtherance of human welfare that these institutions are now permitted to share in the great advances that are being made and that are likely to be made in the future? Until recent years, while the hospitals were appreciative of the contributions which their physicians made to medical progress, yet, as organized institutions, the hospitals themselves played little part in these advances; but now they stand beside the universities and the scientific institutes in educating physicians and in advancing medical science.

Funds and resources must of course be available to exercise properly these functions of education and research. But is it not likely that, when the public fully understands that hospitals, such as this, are engaged not merely in caring for a limited number of the sick poor, but are contributing to the relief of suffering the world over by making better doctors and by increasing knowledge concerning disease, funds for this work will pour into the hospital coffers in greatly increased amounts? "If the public wants good doctors it must help to make them."

I realize that it is like "carrying coals to Newcastle" to reiterate these things which you have already considered for yourselves and about which you have made such wise and far-reaching decisions. The results obtained here in the way of new discoveries and in the improvement of medical education, in the increased service of the hospital to the community, in the ever increasing reputation of your institution must make you very proud and very ambitious for even greater things. The New Haven Hospital has always stood in the front ranks. Its past is an honorable and glorious one. At times its luster may have been dimmed owing to its proximity to a famous university, but in recent years in the great universities the world over the medical faculty has acquired increasing importance. In medical education in this country, the hospital is playing, and will play, an important rôle.

But just as the success of the university is dependent upon the men who comprise its faculty, so the accomplishments of the hospital depend upon the abiilty and energy of the physicians working within its walls. The organization and the equipment may offer opportunities, but the success of the hospital will really depend upon the character of the men who are attracted to join in its activities and upon the breadth of the spirit of service that pervades its atmosphere.

May this hospital in the future, as in the past, have the services of the greatest men in the medical profession. May they be guided by the same broad humanitarian spirit as have their predecessors and may the next centennial bring as marked cause for satisfaction to your descendants as this first centennial has brought to you. "Prosperity to the New Haven Hospital and health and ease to its poor patients."

Rufus Cole
Hospital of the Rockefeller Institute

THE SUBSIDENCE NEAR SHARON SPRINGS, KANSAS

On the morning of March 9, 1926, a certain rancher, living about five miles east of the little town of Sharon Springs on the plains of western Kansas, chanced to see across the fields a dun-colored cloud of smoke. Hasty investigation revealed a newly formed, great yawning hole at the edge of the gently rounded bluff that here looks down on the dry sandy flat of Smoky Hill River. The cloud was dust. Excited word was broadcast by the press that the bottom was dropping out of Smoky Hill River, that a volcanic explosion of some sort was in full blast, or maybe a great gas blowout was in process of blowing.

According to reliable report the opening was at first something over fifty feet in diameter and appeared to be some hundreds of feet deep. Two streams of water from the underflow of Smoky Hill River were cascading into the depths, sounding distantly on rocks below.

On March 11, when Professor G. S. Lambert, of the Kansas University Department of Geology, went to Sharon Springs, the depression was a much enlarged irregular ellipse about 125 feet wide and 250 feet long, the longer axis at right angles to the low river bluff which here trends from south to north. Water filled the lower part of the hole, small springs on the river side adding constantly to the water in the pool. The precipitous cliffs on the upland side of the depression were seen to be formed by dark bluish drab stratified rock and on the side toward the river flat of sandy alluvium. At least two thirds of the large hole occupied a part of the former river bluff, the smaller part projecting into the lower ground of the river plain. Evidence pointed clearly to a subsidence caused by solution of rock material under ground, but

the possible extent and causes of this solution were not evident. Sulphurous fumes had been reported by some of the first observers at the hole, but this is very doubtful and there is seemingly no reason to consider seriously a cause other than the subsidence that frequently accompanies removal of soluble rock by underground water.

The writer visited Sharon Springs on April 13 and spent the following few days in observations at the sink and in neighboring parts of western Kansas and eastern Colorado. He found that the depression at Smoky Hill Basin had appreciably enlarged since the time of Mr. Lambert's visit, being fully 150 by 290 feet in diameter at the top. Numerous side cracks, in part roughly concentric to the depression but in part trending for a distance as much as one hundred yards directly away from it to the south indicated that the size of the opening was slowly but steadily being increased. Indeed, there was a readily observable change during the short period of the writer's study.

A systematic series of soundings of the pond revealed a gradual increase in depth of water to about fifty feet, but in an area comprising about one seventh of the bottom the soundings increased very suddenly to 160 or 170 feet. A survey showed that the depression formed by the subsidence has a volume of a little over one and a half million cubic feet. Taking into account the volume which is occupied by the fallen rock débris, which by reason of its fragmentation may be assumed to fill a space at least 20 to 30 per cent. greater than its original volume, the size of the cavity under ground must be large. The depth from the original surface to the top of the material filling the deeper part of the hole is 245 feet; the depth to the bottom of the original cavity may be 500 feet, although this is only an approximate estimate.

The stratified rock exposed in the walls of the depression at Smoky Hill Basin is the basal part of the Pierre shale. The underlying Niobrara chalk which, according to borings in the vicinity, has a thickness of slightly more than seven hundred feet, is only a little below the surface at this place and it crops out in the Smoky Hill valley not far to the east. The chalk is readily soluble, although the large amount of clay in part of the formation impedes the circulation of water. It is not readily possible for water to enter the chalk in this part of western Kansas where the impervious Pierre shale overlies it, but there is a large area in eastern Colorado where the chalk is exposed at the surface or is concealed only by a thin veneer of Tertiary and Recent sand. The elevation of this Colorado area is more than 4,000 feet above sea level, while the top of the chalk east of Sharon Springs is less than 3,300 feet, the stratified rocks being gently inclined from southwest to northeast so that water entering the chalk in Colorado migrates northeastward, dissolving a part of the chalk as it travels. The water is confined to the porous chalk by impervious shale formations above and below it and it is finally released where the chalk reaches the surface at various places in Kansas. Evidence of the solution of the chalk is found not only in subsidence phenomena but in the large amount of calcite which is deposited along fracture or fault planes in the chalk. It is not improbable that the small faults so common in the Niobrara represent settling following removal of material in solution.

The sudden subsidence at Smoky Hill Basin has attracted attention partly because it is fairly large but more because it is very uncommon in the experience of the plains people. Such subsidences are really by no means rare in regions where underground solution is active, but even in limestone regions like Kentucky it is not common for sudden large subsidence to take place under direct observation; rather it is the evidences of past subsidence that are found on every hand.

Western Kansas does not lack evidence that subsidences have taken place in the past; indeed, there are very abundant marks of local sinking. A few miles northwest of Sharon Springs is an excellent example of an old sink, locally known as Old Maid's Pool. This is a nearly circular depression over eighty feet in maximum depth, approximately three eighths of a mile in diameter at the rim and holding at the bottom a permanent small lake about three hundred feet wide. On all sides the rim forms a divide so that topographically the depression is a very striking feature. In relation to geologic structure Old Maid's Pool corresponds closely to Smoky Hill Basin except that a slightly greater thickness of Pierre shale overlies the chalk. Undoubtedly the origin of the two depressions is the same, but the one antedates the other by several scores or perhaps hundreds of years. There are many other, though generally less distinct and accordingly older, depressions of like character. The so-called "buffalo wallows" which dot portions of the plains are small or large subsidence areas resulting from solution, mostly in the Tertiary sediments. There are some very large subsidence areas affecting many square miles in southwestern Kansas.

RAYMOND C. MOORE

LAWRENCE, KANSAS

SCIENTIFIC EVENTS

THE SOLIDIFICATION OF HELIUM

PROFESSOR W. H. KEESOM writes to *Nature* from the University of Leyden on his work on the solidification of helium as follows:

On June 25 helium was compressed in a narrow brass tube forming communication between two German silver tubes. The brass tube and part of the two German silver tubes were in a liquid helium bath. At a pressure of 130 atmospheres the tube system appeared to be blocked. When the pressure was diminished by 1 or 2 atmospheres the tube system was open. The temperature of this experiment was somewhat uncertain. By diminishing the pressure of the liquid helium bath the same phenomenon was observed at a temperature of about 3.2° K. at 86 atmos., and at a temperature of about 2.2° K. at 50 atmos. From the regularity of the phenomenon it appears that we were observing the solidification curve of helium. This method of observing solidification has indeed already been used by Kamerlingh Onnes and Van Gulik in preliminary measurements on the curve of solidification of hydrogen.

A repetition of the experiment on July 1 confirmed the early observations. At 4.2° K. helium solidified at 140 atmos. The solidification curve was prolonged to 1.1° K., and the helium solidified then at 26 atmos. The exact numerical data will be given elsewhere. The solidification curve bends so that at the lower temperatures it shows a tendency to become parallel to the axis of the temperatures. So far as can be ascertained from these observations, helium is expected not to have a solid-liquid-gas triple point.

Finally, helium was compressed in a glass tube provided with a magnetic stirrer after the pattern of Kuenen. The observations on the solidification of helium were confirmed. The stirrer was seen to stick when the helium solidified. In one experiment part of the substance was liquid and part solid. One could hammer the solid block with the stirrer that was in the liquid part. A limiting surface between the solid and the liquid could not, however, be seen. Solid helium forms a homogeneous transparent mass, the refractive index of which probably differs extremely little from that of the liquid.

RADIATION FROM THE CARBON ARC

AN investigation is being made at the Bureau of Standards of the radiation from the carbon arc, a matter of great importance in the treatment of diseases by exposure to light, especially sunlight. However, sunlight can not always be obtained, hence the demand for an artificial source approaching sunlight in its characteristics.

The investigation is being made in duplicate: (1) By mapping the ultra-violet spectrum by means of a quartz spectroradiometer, and (2) by measuring the spectral components of the total radiation emitted by the arc, by using a thermopile and screens which completely absorb certain spectral regions and freely transmit others.

Thus far studies have been made of the standard carbons on the market, *viz.*, "white flame," "red flame," "yellow flame," "blue flame" and "neutral core" carbon electrodes; also several special carbons with cores of nickel, tungsten, etc. The effect of varying the current has been studied, using 15, 30, 60, 90 and 122 amperes.

The high-intensity arc (120 amperes) has been found to be closest to the sun in spectral composition. It emits considerable radiation of wave lengths longer than 4μ, which are not in the solar beam, but this can be eliminated easily by using a window of fused quartz, which absorbs the long infra-red rays.

THE COMMITTEE ON INTELLECTUAL CO-OPERATION OF THE LEAGUE OF NATIONS

THE following despatch from Geneva, dated July 29, appeared in a recent issue of *The Boston Transcript:*

The intellectual and scientific leaders of the world are attending this week the meeting of the committee on intellectual cooperation of the League of Nations in Geneva. The committee has taken steps toward coordinating the intellectual work of the world under the chairmanship of Professor H. A. Lorentz, one of the world's most noted physicists and secretary-general of the Netherlands scientific society. Others present were Dr. Albert Einstein, representing Germany; Dr. Vernon Kellogg, permanent secretary of the National Research Council, representing the United States; G. A. Murray, professor of Greek at Oxford, representing Great Britain, and Mlle. K. Bonnevie, zoologist, representing Norway.

Questions affecting universities, especially concerning progress in arts, letters and sciences and also policies in bibliography, were discussed. Exchange of students between countries was urged as the most effective means of advancing the intellectual life of the nations by the American delegate, Dr. Vernon Kellogg. "In my opinion no more important step toward fundamental development in internationalism has been made in recent times than the multiplication of international scholarships for the élite of the younger generation of scholars."

To facilitate the development of international scholarship, the committee considered the possibility of easier passport regulations, less expensive visas and reductions in transportation rates for international students, and encouraged the formation of international student associations. The committee also urged the establishment of university information offices by all countries and the cultivation of courses in internationalism at all universities.

An important report on scholarships was presented on behalf of Mme. Curie, who is absent in Brazil. In her recommendation she points out that since science has become so highly specialized, students must go to the particular places where they can obtain the best training for the subject in which they are interested, regardless of whether it is at home or abroad. She advocates two kinds of scholarships; one for the student who is just beginning his research, the other for the advanced worker

who may already have accomplished some research but needs financial backing in order to continue. She recommends a relaxation of the insistence on formal "credits" prevalent in some places and a stressing of the student's ability to work independently and find out for himself.

The delegates agreed that to inform one scientific worker concerning the researches of others is a major problem of science to-day. This is considered of fundamental importance, and extensive work on a bibliography in economic sciences was proposed as the subject of an international conference to be held at a later date. Coöperation between the various countries in the coordination of physical and biological bibliography is already well under way.

M. J. Destree, formerly minister for sciences and arts in Belgium, called attention to danger to scientific records due to the bad quality of paper and ink used since the war in publication of work. Mlle. Bonnevie reported on an investigation carried on in Norway, showing that the present types of paper will last less than a hundred years.

The proposal by Professor Arthur Korn, the German physicist, to synchronize all important timed operations in the world, presented by Professor Einstein, was favorably received.

The Orient, represented for the first time at a meeting of the international committee by Sir J. C. Bose, the well-known plant physiologist of India, received considerable attention; he will lecture at the University of Geneva on his discoveries in the vital processes of plants.

THE GOLDEN JUBILEE OF THE AMERICAN CHEMICAL SOCIETY

A large number of foreign chemists will join with the chemists of this country in celebrating at Philadelphia during the week of September 6 the Golden Jubilee of the American Chemical Society, at which four thousand scientific men are expected to be in attendance.

Among those already here is Sir James Colquhoun Irvine, F.R.S., principal of the University of St. Andrews and head of its department of chemistry, known especially for his work on the chemical constituents of the carbohydrates. Sir James is lecturing at the summer session of Columbia University and will also speak on the rôle of chemistry in world affairs at the Institute of Politics at Williamstown. At the Sesquicentennial gathering of the American Chemical Society he will describe the growing interdependence of English and American chemists as shown by the developments of the last half century.

One member of the German delegation, Dr. Leonor Michaelis, professor of biological chemistry in the University of Berlin, is also in New York, as well as Dr. Ernst Cohen, professor of physical chemistry in the University of Utrecht. Both Professor Michaelis and Professor Cohen are lecturing at Columbia University during the summer.

Dr. Michaelis is also professor of biochemistry in the Aichi Medical University, Nagoya, Japan, and is the author of numerous research papers and monographs dealing with the physical chemistry of living matter. Dr. Cohen is president of the International Union of Pure and Applied Chemistry, which will meet in Washington during the week following the jubilee. This will be the first meeting of the Union, which consists of a council and an assembly, held in the United States.

Every civilized land will send delegates to the Philadelphia session. Among the French chemists to come are Dr. Camille Natignon, and Dr. Gabriel Bertrand. Dr. Matignon is editor-in-chief of *Chimie et Industrie,* heads a research laboratory in the Collège de France and was recently elected to the French Academy of Sciences. He is known for his work in mineral chemistry. Dr. Bertrand is professor of biological chemistry at the Sorbonne, and is chief of the service of biological chemistry of the Pasteur Institute. Dr. Bertrand's investigations into the venoms of batrachians and reptiles resulted in his discovery of vaccination against the bites of venomous serpents and has served as the scientific basis for subsequent developments made by others.

Denmark will send J. N. Bronsted, professor of physical chemistry at the Royal Polytechnic Institute, Copenhagen.

From Switzerland will come Peter Debye, professor of theoretical physics at the Technische Hochschule, Zurich. Professor Debye is the author of numerous researches in physical chemistry, and is the leading exponent of the theory of the electrical structure of matter as applied to the problems of specific heats, dielectrics and X-ray analysis.

Professor Bronsted and Professor Debye are also lecturers this summer at Columbia University.

Foreign experts who will speak at the raw rubber symposium are Dr. A. van Rossem, of Delft, Holland, and Dr. Henry P. Stevens, of London, consultant for the British Rubber Growers' Association. Canada will be represented by Dr. G. S. Whitby, of McGill University.

Heading the delegation from Italy will be Prince P. Ginori Conti, who will address the society on September 6, on "The Development of Chemical Industry in Italy."

The society has elected to honorary membership fourteen prominent chemists representing the United States, England, Holland, Scotland, Italy, Switzerland, Japan, Czechoslovakia and Belgium. They are: Ira Remsen, president-emeritus and professor-emeritus of chemistry, Johns Hopkins University; Theodore W. Richards, professor of chemistry, Harvard University; Edgar Fahs Smith, provost-emeritus of the University of Pennsylvania; W. Lash Miller, head

of the chemical department, University of Toronto; Charles Moureu, of the Collège de France; Paul Sabatier, of the University of Toulouse; Bohuslav Brauner, of the University of Prague; Guiseppe Bruni, professor of chemistry at the University of Milan; Ernst Cohen, professor of chemistry at the University of Amsterdam; Frederick G. Donnan, professor of general chemistry at University College, London; Sir James Colquhoun Irvine, principal and vice-chancellor of the University of St. Andrews, Scotland; Joji Sakurai, of the Imperial University of Japan; Frederick Swartz, senior professor of chemistry of the University of Ghent, Belgium.

The new honorary members will be present at the Philadelphia meeting of the society. Foreign chemists attending plan to lecture before universities and scientific bodies in various cities of the country.

SCIENTIFIC NOTES AND NEWS

Sir Robert Philip, of Edinburgh, was elected president of the British Medical Association at the annual meeting, which opened at Nottingham on July 20. He succeeds Dr. R. G. Hogarth, senior surgeon of the Nottingham General Hospital.

Professor Paul Sabatier, of the University of Toulouse and Nobel prizeman in 1912 for chemistry, has been awarded the Albert Medal for 1926 of the Royal Society of Arts, in recognition of his distinguished work in science and of the services to industry rendered by his researches in physics and chemistry, which laid the foundation of important industrial processes.

M. Pierre Weiss, formerly director of the Zurich Polytechnic Institute and since its reorganization professor at the University of Strasbourg and director of the institute of physics, has been elected a non-resident member of the Paris Academy of Sciences in the place of the late M. G. Gouy.

Dr. Richard Schumann, professor of geognosy and spherical astronomy in the University of Vienna, has been elected a foreign member of the Hungarian Academy of Sciences.

Dr. Richard Willstätter, professor of chemistry at Munich, has been elected a member of the Dutch Academy of Sciences at Harlem.

Major-General Sir Matthew H. G. Fell has been appointed director-general of the British Army Medical Services, in succession to the late Lieutenant-General Sir William B. Leishman.

Dr. Wolfgang Kohler, professor of philosophy in the University of Berlin, who recently returned to Germany after having spent a year in the United States lecturing at various universities, has been invited by Harvard University to lecture there during the year 1926–27.

H. D. Meiser, who has been filling a temporary appointment as state geologist of Tennessee, has been appointed geologist in charge of areal geology of the U. S. Geological Survey, to succeed Sidney Paige, who recently resigned.

Dr. H. G. Miller, biochemist in charge of animal nutrition work at the Oregon Experiment Station, Corvallis, has resigned to accept a position as biochemist for Procter and Gamble at Ivorydale, Ohio.

The council of the Yu Wang Fu Association (an organization comprising those who have worked at the Peking Union Medical College of the Rockefeller Foundation) has elected the following officers: *President,* A. E. Cohn; *Secretary-Treasurer,* F. C. McLean; *Members of the Council,* F. W. Peabody, H. R. Slack and E. V. Cowdry.

Dr. Francis G. Benedict, director of the nutrition laboratory of the Carnegie Institution of Washington, recently left Boston to attend the twelfth International Congress of Physiology to be held at Stockholm in August. He will then make an extended tour of scientific institutions in the different European countries, and will return to Boston about January 1.

Dr. N. L. Bowen, of the geophysical laboratory of the Carnegie Institution of Washington, is spending the summer in field work on the igneous rocks of the British Isles, in company with several British petrologists.

Dr. O. F. Cook, J. W. Hubbard and F. C. Baker have returned to Washington after three months in the West Indies and Central and South America. They report the discovery of new types of cotton that may be valuable to the cotton industry of the United States; and that tapping experiments on 20-year-old Hevea rubber trees on the north coast of Haiti in the last two years have given results comparable to those on the East Indian plantations, which indicates that it is not impossible to produce Para rubber in suitable locations in the West Indies, Central America and Mexico.

Austin H. Clark returned to Washington on July 28 from Denver, Colorado, where he attended a meeting of the advisory committee on source bed studies which will direct a project for research work to be undertaken jointly by the American Petroleum Institute and the American Association of Petroleum Geologists, in cooperation with the National Research Council. Mr. Clark is a member both of the full committee and of the supervising committee which will have immediate charge of the work.

DEAN JULIAN PARK, of the University of Buffalo, is spending the month of August in Geneva, Switzerland. He will give some lectures at the Geneva School of International Studies, of which he is a member of the board of trustees.

MISS CATHERINE LUCAS, of the London School of Hygiene and Tropical Medicine, has been awarded the traveling scholarship of London University. She will spend the school year 1926–1927 in research in protozoology with Dr. R. W. Hegner at the Johns Hopkins School of Hygiene and Public Health.

DR. T. A. JAGGAR, director of the Hawaiian Volcano Observatory of the U. S. Geological Survey, recently gave an illustrated lecture at the Interior Department on "The Recent Eruption of Mauna Loa."

DR. ST. JOHN, physicist of the Mt. Wilson Solar Observatory, is in residence at the University of Michigan for four weeks, to lecture on the various experimental tests of the Einstein theory, and also upon the contribution of the modern ideas of atomic structure to the solution of problems of cosmic physics.

DR. F. A. BATHER, president of the British Geological Society, unveiled a mural tablet to William Smith, on July 10, at 29 Pulteney Street, Bath. After the unveiling ceremony, there was a luncheon at the Guildhall, followed, in the afternoon, by an address by Dr. Bather at the Royal Literary Institution on William Smith and his work.

DR. WILLIS T. LEE, geologist of the United States Geological Survey, died at his home in Washington on June 17, in his sixty-second year.

THE death is announced of M. Albert Frouin, who for twenty-six years has been director of the physiological laboratories of the Pasteur Institute, Paris.

A TRANSLATION from the Portuguese of Alexandre Herculano's "History of the Origin and Establishment of the Inquisition in Portugal," made by the late John Caspar Branner, professor of geology at Stanford University, from 1891 to 1915 and from 1898 to 1915 vice-president and president of the university, has been issued by the Stanford University Press. The translation was made during the interval between Dr. Branner's retirement from the presidency in 1915 and his death, which occurred in 1916.

DR. R. M. COURTAULD, a Cambridge medical graduate, has given an endowment to Pembroke College for the purpose of establishing a studentship in mathematics or physics. The student appointed will be called the "Stokes student," in memory of Sir George Gabriel Stokes, the distinguished mathematician, formerly master of the college. No distinction of sex will be made in awarding the studentship, but if a man is appointed he will be required to become a member of the college. The value of the student ship will be between £400 and £450 a year, and the tenure will be for three years, with possible renewal for a further five years.

FOR reasons of economy the government of New South Wales has practically abolished Sydney Observatory. Mr. W. E. Cooke, who has been the director for many years, retires on account of age at the end of August, 1926. Mr. Raymond, chief assistant, will be the only official who will remain at the observatory, all the other members of the staff being transferred to other departments of the government. Mr. J. Nangle, superintendent of technical education, will hereafter be in charge, but it is understood that all research now ceases.

THE next International Congress of Agriculture, which met in Germany last April, will be held in Russia in the year 1930.

THE thirty-sixth French Congress of Surgery will be held at the Paris faculty of medicine, under the presidency of Professor J. L. Faure, from October 4 to 9.

THE U. S. Public Health Service is arranging the program for the First Pan-American Health Conference to be held in Washington, D. C., September 22–29. An official call for the conference has been made by Surgeon-General Hugh S. Cumming, of the U. S. Public Health Service, who is director of the Pan-American Sanitary Bureau. The conference is in a measure preparatory for the Eighth Pan-American Sanitary Conference, to be held at Lima, Peru, in 1927. Among the subjects for discussion will be malaria, hookworm, public health measures and administration. The conference will be held by directors of health in the various South and Central American countries. Among the suggestions already received for consideration at the conference are health administration and organization, pure water supplies, safeguarding milk, disposal of sewage, infant mortality and registration of communicable diseases, births and deaths, yellow fever, bubonic plague and smallpox.

THE first session of the School of Tropical Medicine of the University of Porto Rico, under the auspices of Columbia University, in San Juan, will begin on October 1. At the opening exercises to be held in the school's new building on September 22, there will be addresses by the Honorable H. M. Towner, governor of Porto Rico, the Honorable An-

tonio R. Barceló, president of the Porto Rican Senate and chairman of the board of trustees of the University of Porto Rico, and Dr. William Darrach, dean of the College of Physicians and Surgeons, Columbia University. The representatives of Columbia University at these exercises will include, besides Dean Darrach, Professor James C. Egbert, director of university extension, Dr. James W. Jobling, professor of pathology, and Mr. Frederick Coykendall, of the board of trustees.

A correspondent writes: "The International Society for Photogrammetrie will have its general meeting at the Technische-hochschule of Berlin-Charlottenburg, from November 22 to 25. The importance of photogrammetrie for surveying, and particularly in the form of stereo-photogrammetrie for surveying mountainous regions or hydraulic projects, has been proved. Its methods are also used for criminological measurements, for Röntgen ray measurements, and for the measurement of ocean waves, etc. This congress shall have a general exhibition showing the various applications of photogrammetrie, and to have papers presented wherein will be given the results of the more recent research. Particular attention will be paid to photogrammetrie in connection with surveying by means of photographs taken from airplanes. Any one interested in attending the congress, having papers to present, or exhibiting instruments, can secure further information by corresponding with Regierungsrat Koerner, Berlin-Halensee, Karlsruher Str. 1."

A congress of chemists, arranged by the Society of Chemical Industry in connection with its forty-fifth annual meeting, was held in London, from July 19 until July 23. A joint meeting of the Biochemical Society with the London Section of the Society of Chemical Industry, was held on July 20, devoted to a discussion on hormones; it was opened by Dr. H. H. Dale, F.R.S., with a paper on the experimental study and use of hormones. He was followed by Dr. H. W. Dudley, who dealt with the chemistry of the pituitary gland and of insulin; by F. H. Carr, who discussed the commercial production of hormones; by Dr. H. A. D. Jowett, who spoke on the history of adrenalin; by Professor G. Barger, F.R.S., whose subject was recent progress in the chemistry of thyroxin; and by Dr. J. W. Trevan, who explained the biological assay of hormones.

In reply to a question by Mr. H. Williams in the British House of Commons, it was stated by Mr. Ormsby-Gore, under-secretary for the colonies, that arrangements had been made by the Department of Scientific and Industrial Research for communicating regularly published and other information as to the work done under its auspices to Dominion Government research organizations and to the principal unofficial research centers. Similar communications are sent to the governments of India and the colonies. In return valuable information is being received by the department from the oversea parts of the empire. As regards agricultural research somewhat similar arrangements for the exchange of information between organizations in this country and overseas are in force; and it is proposed that a conference on the subject of inter-imperial cooperation in agricultural research should be held in the autumn of 1927. Invitations to this conference were issued last year to the governments of the dominions, colonies and protectorates.

Harlan I. Smith, accompanied by T. B. Campbell, of the engineering department of the Canadian National Railways, is at present at Kitwanga, B. C., where he is in charge of the preservation of Gitksan Indian totem poles in what may be termed an out-of-doors museum. This is both a place of anthropological interest and a tourist attraction. There are seventeen totem poles and two totem figures at Kitwanga. The work of preservation is carried on for the Department of Indian Affairs under the direction of Dr. Duncan Campbell Scott, F.R.S.C., deputy superintendent general. The actual work is done by the Canadian government museum, which is represented by Mr. Smith, who is in charge of field operations. This work was begun at Kitwanga in 1925 and will probably be finished there this season. Next year it is expected the totem poles of Gytsegyucla will receive attention and later those of Hagwelget, Kispiox, Hazelton, Kitselas and Kitwancool. In all there are about thirty-three which can be viewed from passing trains of the Canadian National Railway or a total of over one hundred within fifteen miles automobile ride of stations on that line, which is probably the only line in the world from which totem poles may be seen.

The American Institute of Chemists will hereafter require a minimum of six years of collegiate and graduate training with five years of professional practise for admission to the rank of fellowship in the institute. This restriction will not be applicable to those who received their training prior to 1926. These will be admitted on four years of collegiate training.

The Royal Observatory of Belgium, which was founded by the Dutch government in 1826, celebrated its centenary on June 8.

UNIVERSITY AND EDUCATIONAL NOTES

HARVARD UNIVERSITY has been appointed residuary legatee of the estate of the late Augustus Coe Gurney, a former member of the Paris bankers, Morgan, Harjes and Company, who died on July 5. It is reported that the share of Harvard University will amount to two million dollars.

AT the University of Chicago, Dr. J Harlen Bretz has been promoted to a full professorship of geology, and Dr. I. S. Falk, of hygiene and bacteriology; E. P. Lane, mathematics, and C. R. Moore, zoology, have been made associate professors.

DR. THOMAS A. STOREY, of New York University, who for ten years after his graduation served as director of the gymnasium of Stanford University, has been recalled to Stanford as professor of hygiene and physical education for men.

DR. DON M. GRISWOLD, who has been on a year's leave of absence from the University of Iowa, has resigned his position as state health commissioner of Iowa, effective on July 1, and will return to his post at the university. The governor has appointed Dr. Henry Albert, director of laboratories, University of Nevada, to succeed Dr. Griswold. Dr. Albert is a graduate of the University of Iowa, where for many years he was head of the department of bacteriology.

DR. J. KIMBALL YOUNG joined the faculty of the University of Wisconsin on July 1 as associate professor of economics.

AT Western Reserve University, the following announcements were recently made regarding the department of biology: Dr. C. H. Otis has been given leave of absence for the coming year; Dr. J. P. Visscher has been appointed associate professor; Dr. Lloyd Ackerman has been appointed assistant dean, and Mr. J. M. Odiorne and Mr. R. C. Gilmore have been appointed instructors.

GEORGE PATCHIN has been appointed principal of the Sir John Cass Technical Institute, London, in succession to Dr. C. A. Keane, who has retired.

DISCUSSION

LOGARITHMS AND PRECISION

IN SCIENCE[1] Professor Karl Pearson is quoted as follows: "In a certain sense the day of logarithmic tables to 4, 5, 6 or 7 figures is past . . . What are used and are often badly needed are logarithmic tables to 10, 15 or 20 figures." A couple of weeks later Professor Satterly, in SCIENCE, wrote under the heading, "How many Figures are Significant?": "The research worker trained without a course in this subject (theory of measurements), often wearies the patience of his readers with an absurd number of 'significant figures' in his numerical work."

[1] Vol. LXI, No. 1568, p. 59.

In view of these statements it may be of service to consider the precision of measurements corresponding to different numbers of significant figures. Starting with one of the simplest cases, "good linear measurement" may be taken as requiring six digits, indicating a precision of one part in a million. With ten digits the population of the earth may be stated to the last individual, but since our knowledge of that number for a given date probably does not exceed seven significant digits, that marks an upper limit to the accuracy of the data of eugenics.

The volume of the earth to the nearest cubic yard requires only about twenty-one digits, while two more digits will express the distance to the Large Magellanic Cloud in feet; the latter number being also the approximate number of electrons in one gram of matter, quoting Dr. W. R. Whitney, of the General Electric Company.

In comparison with what is probably the longest string of significant digits ever computed, *viz.*, William Shank's value of π to 707 decimal places, the number of cubic centimeters in space-time of the Einstein Theory is relatively small, requiring much less than one hundred digits. But the radius of space-time and the number of electrons in a gram have the common property of being unknown beyond the first digit so are not accurate within ten per cent., thus illustrating the difference between results of observation and computation. For these observational results the humble slide rule, accurate to three digits, is much too refined for use, while measurements of any sort are relatively few where the ten place logarithm table is not far beyond the utmost attainable precision of the observers.

A few years ago a geometry teacher computing the length of tether of a donkey at the edge of a circular pond grazing over a given area gave the result to eighteen digits. Recently a reporter, learning of the discovery of a fifteen million year old lizard, announced that it was born in 14,998,074 B. C.

It is not an accident that decimal points are not mentioned above, since precision of measurement from the viewpoint of fractional precision is independent of size of the quantity measured, whether it be the radius of space-time or the distance between electrons within the atoms.

A careful examination of the observation errors in a given problem ought to yield in general a fair estimate of the precision, even if the problem is the prosaic task of counting individuals, and the more imposing the array of significant figures, the greater the obligations of the computer to defend his results.

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THE NAMES SIMIA, S. SATYRUS AND PITHECUS

The attention of the zoological profession is invited to the fact that the proposition is before the International Commission on Zoological Nomenclature to reopen the case of *Simia*. In its present form the proposition is for the commission: (a) absolutely to suppress the generic names *Simia* and *Pithecus* and the specific name *Simia satyrus*, on the ground that retention of these names and the application of the rules to them will produce greater confusion than uniformity; (b) to insert into the Official List of Generic Names, ***Chimpansee*** Voigt, 1831, 76, for the chimpanzees, ***Pongo*** Lacépède, 1799, type ***pygmaeus*** 1760, for the orang-utans and ***Macaca*** Lacépède, 1799, type ***sylvana*** 1758, for the Barbary ape.

The argument before the commission gives an extensive historical review of the subject; this will be published in Bulletin 145, Hygienic Laboratory.

Briefly summarized, the argument maintains: (1) that because of the importance of the Primates in connection with investigations on infectious diseases, the nomenclature of certain genera has passed far beyond a status in which this subject is of importance only to zoologists in general and to mammalogists in particular; (2) that it is absolutely essential that unambiguous names be adopted internationally for experimental animals used for studies dealing with problems involving the life and death of human beings; (3) that the names *Simia, Simia satyrus* and *Pithecus* are so confused in zoological literature as to preclude hope of reasonable uniformity in their use in zoological, bacteriological, serological and public health work; (4) that the safest solution is to suppress these names entirely; (5) and that the International Commission should select thoroughly unambiguous and suitable substitutes which will preclude possibility of confusion in interpreting results as reported by bacteriologists and others in different countries—results which deal with human life.

The secretary will delay announcement of final vote until about September 1, 1927, in order to give to zoologists, bacteriologists and others who may be interested time to consult the premises formulated in Bulletin 145, and to express their views to the commission. Application for copies of Bulletin 145, Hygienic Laboratory, should be addressed to "Surgeon General, U. S. Public Health Service, Washington, D. C."

C. W. Stiles,
Secretary to Commission

Hygienic Laboratory, Washington, D. C.

SAND FLOTATION ON LAKES

In connection with the articles on sand flotation which appeared in Science on April 16 and June 4, 1926, it may be stated that this phenomenon has been observed on two lakes in northern Wisconsin; it was noted on Trout Lake on July 2, 1925, and again on May 9, 1926, and on Tomahawk Lake on May 15, 1926. On July 2, 1925, some biological observations covering an area about four hundred meters long and one hundred meters wide were made along the shore of Trout Lake, and patches of floating sand were found over this entire area; no attempt was made, however, to ascertain the full extent of the water thus affected. On May 15, 1926, patches of floating sand were found along the shore of Tomahawk Lake, covering an area about two hundred meters long and fifteen to twenty meters wide; it was estimated that the floating sand covered between five and ten per cent. of the surface of the water within this area. The patches ranged from one centimeter to about five centimeters in diameter. Sand grains of various sizes were found in this material, the largest measuring 2 x 1.2 x 1 millimeter.

In both lakes the floating sand was found along sandy shores and beaches, and there was a moderate offshore wind in each instance, to which agent the phenomenon was attributed.

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SCIENTIFIC BOOKS

An Introduction to Cytology. 2d edition. By Lester W. Sharp. New York, McGraw-Hill Book Co., 1926. Pp. xiv + 581.

A new edition of this widely used work will be heartily welcomed. The book has been largely rewritten and its scope has been in some respects materially extended. Especially noteworthy are the fuller consideration given to discussions of the physico-chemical structure of protoplasm and of cytoplasmic inclusions in the light of recent studies; the author's modified attitude toward the achromatic mechanism concerned in mitosis; the illuminating discussion and summary of meiosis and the more extensive review of our knowledge of animal cytology. As in the former edition, the illustrations are admirably chosen and technically excellent. An important improvement is the inclusion of the bibliography in one alphabetic list.

The author has evidently felt the difficulty of compressing within a still very limited space the results of research in so vast a field. Necessarily his discussions are abridged at times to not greatly more than a list of the investigations on a particular topic. Frequently readers will wish that it had been possible to clothe the meager skeleton of summary with somewhat more of the flesh of discussion. The alternative, of course, was an increase in bulk and expense that would have rendered the work less suitable for use as a text-book. As it stands, it is a masterpiece of organization and summarization and at the same time surprisingly adequate as a volume of reference.

However near perfection a piece of work, divergent opinions will persist upon various points regarding which the author has been compelled to take a stand. A few matters of difference, trifling or otherwise, may be mentioned.

At several places in the book there is a confusion of *cell plates* with *cell walls* and of *planes* with *lines*. One may venture to regret the use of such redundant and awkward expressions as *sperm cell, egg cell* and *spore cell.* The diagram of a cell on page 56 is unsatisfactory to a botanist because of the omission of plasma membrane and wall. It may be urged that walls are not present about all cells, but neither are centrosomes or plastids invariable cell constituents, yet these are included in the diagram.

The word *homology* has a sharply defined meaning, generally accepted; but it is difficult to determine what definition of the word is in the author's mind when he speaks of the protozoan body and ordinary tissue cells as not homologous (p. 59), of the bodies of *Vaucheria, Cladophora* and *Stigeoclonium* as "surely homologous" (p. 73) and of the protozoan as homologous with the whole man (p. 79). The term "homologous chromosomes" is also misleading, since little if anything is known as to the homologies of chromosomes; but in this respect a well-established custom is followed.

Unfortunate, too, is the definition of "the prophase" as covering the whole series of *prophases,* and similarly for "the anaphase" and "the telophase." Sharp's usage in this respect in his first edition has led some younger writers into confusion, and the error is preserved in the present revision. Strasburger's definitions of *prophases, anaphases* and *telophases* as series of stages have been adhered to by practically all careful writers since the terms were introduced; and properly, since a succession of transformations is not a *phase.* The use of "the metaphase" as substantially synonymous with "equatorial-plate stage," on the other hand, is justified by rather wide usage. The shift that has taken place in the meaning of this term is also, however, to be deplored; "equatorial plate" needs no synonym; and it is preferable to retain the original significance of "metaphases" as including the stages from the arrangement of the chromosomes in the equatorial plate to the moment of the completed separation of the daughter chromosomes.

The author finds himself in difficulties, as we all do, in attempting to classify the substances found within a living cell. He says truly (p. 50):

> The fundamental fallacy involved in much of the speculation on this subject lies in attributing the properties of a system to one or more of its constituent elements, and consequently in attempting to draw a sharp line between ''living'' and ''lifeless'' components. . . . It can not be emphasized too strongly that protoplasm is a *living system* of components which of themselves are non-living.

He treats, nevertheless, with unneeded tenderness some of the once helpful but now largely meaningless classifications proposed for "living," "less actively living" and "non-living" constituents of protoplasm and even adopts some of the terminology based upon these classifications. The result is a feeling on the part of the reader of a certain lack of consistency. Similar difficulties attend the discussion of cytoplasm, which seems to be considered as not including, for example, vacuoles—although it is pointed out (p. 31) that "any distinction between large vacuoles, alveoles and ultramicroscopic colloidal masses of the same material is more or less arbitrary." Cytoplasm, like protoplasm, can not workably be so defined as to exclude substances that are or are thought to be "non-living."

Perhaps the most interesting feature of the book to the critical reader—as it evidently is to the author—is the latter's definite espousal of the "organismal" viewpoint. He reviews at some length the ideas of previous writers whom he classes as advocates respectively of the "cell theory" and the "organismal theory." While this classification may be pedagogically useful, it is evident from Sharp's clear analysis that, like most classifications, it is strictly artificial. The views of the writers cited represent in fact an intergrading series of conceptions ranging from Schleiden's and Schwann's version of the cell theory to notions that verge upon vitalism. The older of these discussions were important in their time as statements and clarifications of problems to be attacked; the later ones are far from indispensable. Enough facts have been accumulated to enable us to deal concretely with biological phenomena. It is clear, for example, that those plants and animals which represent the dominant trend of evolutionary development are composed of cells, usually but not

always uninucleate, which despite their interrelations grow, divide and otherwise function as units. It is likewise clear that certain groups of organisms illustrate phylogenetic possibilities of a very different nature. The concept of the cell, based upon conditions in "higher" animals and plants, can, to be sure, be applied without serious distortion to the plasmodium of a slime mold or to the coenocyte of Vaucheria. Whether or not this possibility is insisted on, cytological study at present concerns mainly the predominant "cellular" type of organization. A clear analysis of the structure and functions of organisms so constituted, whatever may be true of other types of organization, is possible only in terms of cells. Witness the misty results of attempts to make such an analysis in other terms. It is interesting that, although Sharp announces himself an organismist and conscientiously reproclaims his faith from time to time, his discussion of almost all the problems he deals with is in terms of cell structures and cell functions. From one point of view it is immaterial if a biologist thinks abstractly of a plant or animal as a whole which organizes itself into cells, so long as he actually treats the cells as units which by growing, dividing, remaining adherent and undergoing differentiation organize themselves into a plant or animal.

Viewed in another aspect, however, the difference between these conceptions is more important. Experience shows that progress is to be made in the study of complex organisms by accepting the fact of cellular organization and by using this fact as a means of analysis; whereas the concept of "the living system as a whole" exercising a mysterious control over its cells leads as to an inevitable corollary to the doctrine that "the organism is more than the sum of its cells"; and the whole-hearted acceptance of this in turn to confused thinking, mysticism and sterility. There is good reason to hope that our author's interesting adventure into this perilous field will end in a realization of the troubles ahead.

CHARLES E. ALLEN

SCIENTIFIC APPARATUS AND LABORATORY METHODS

IMPROVEMENTS IN ALPHA-RAY TRACK APPARATUS

THE apparatus recently described by the writer and N. E. Sowers[1] has been still further simplified and standardized through the experience of the past few months, and hence a brief note regarding its present form seems justified.

[1] *Jour.* Optical Society of Amer., Vol. 11, No. 2, Aug., 1925; Proc. Ind. Acad. Sci., Vol. 34, 1925.

Its appearance in elevation is shown in Fig. 1a. The containing vessel is blown into form from a pyrex glass Erlenmeyer flask. A tungsten wire C, making contact with the upper inside flat surface, forms one electrode M, while another wire D, fused through the body of the flask, forms the other electrode N, which in reality is the surface of the water. A nipple P is placed near the surface M and through it is supported the glass cane on the inner end of which is mounted the radioactive material so essential to the success of the experiment. The manner of mounting this cane is shown in Figs. 1a and b. The tap T is for filling the vessel with water, which is readily done by compressing the bulb RB. The water level should be at N, distant about 1.3 cm from M.

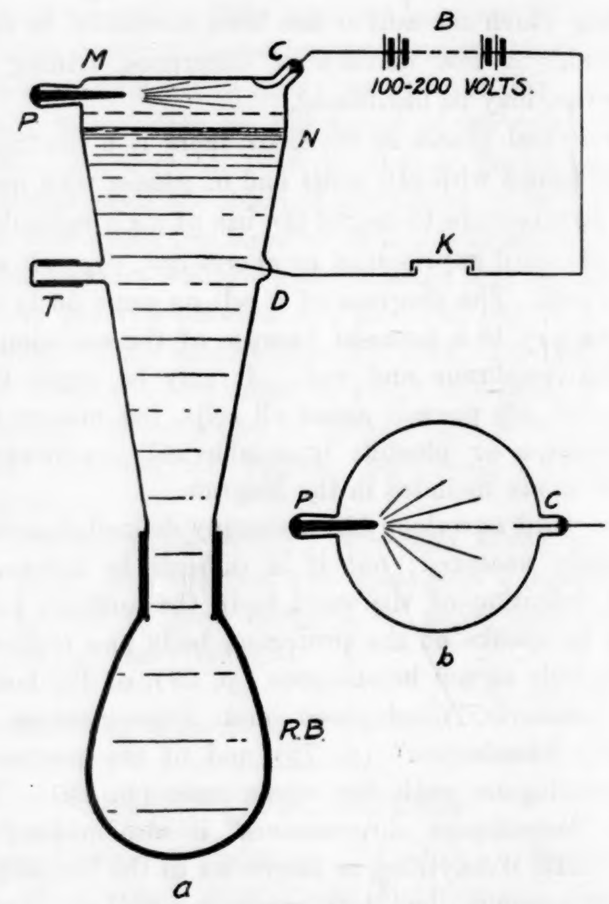

FIG. 1

The necessary electrical connections are also shown in Fig. 1a. For best results one hundred to two hundred volts (an ordinary B battery in radio) should be placed in the circuit, though good results are obtained by connecting directly to a 110 D.C. source. The 100 A.C. lighting source will not work. In making the electrical connections it is not necessary to pay any attention to polarity, or to earthing, or, as was commonly supposed, to arrange for *closing* or *opening the circuit* at proper intervals when producing the alpha-ray tracks. The space between the plates M and N must be illuminated. A shielded 60 watt, 110 volt, mazda lamp answers very well. Fig. 1b is a view of the top looking down.

The procedure in operating the apparatus is briefly as follows: With the connections as in Fig. 1a, and the surface M previously wetted by tilting the apparatus, compress the bulb RB gently and then release it suddenly. Repeat this until (by trial) the proper expansion ratio is obtained, whereupon the tracks will appear freely, being very distinct and persisting for some moments.

When the radium salt is mounted, as was formerly done, on the inner tip of P and *not protected,* the emanation escaping soon contaminates the expansion chamber with the result that the ray tracks proceed from random points in addition to those from the original source, thus adding confusion to the picture. The radium, being exposed to the moisture of the enclosure, or at times in actual contact with the water, is in danger of being detached and lost.

Various types of protecting cavities have been tried, but all proved undesirable, since it seemed to be impossible to make a housing with a sufficiently thin window to allow the passage of the alpha particles. The solution came, however, from a suggestion made by L. P. Garner, a graduate student in electrical engineering. This mounting is of pyrex. The glass cane carrying the radium salt is inserted through the nipple P (Figs. 1a and b) and fused in position.

A protected source of alpha particles thus constructed apparently leaves nothing to be desired. The emission of alpha-rays seems to be unaffected by the thin glass window. The troublesome emanation is eliminated and with it the random ray tracks. The active salt is effectively protected from moisture and subsequent loosening. When such a mounting is used there results a clear-cut fan-shaped grouping of alpha-ray tracks, that may be reproduced at will and which seems to be unaffected by time.

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SPECIAL ARTICLES

FURTHER STUDIES ON ADRENAL INSUFFICIENCY IN DOGS[1]

DURATION OF SURVIVAL OF CONTROL ANIMALS NOT SUBJECTED TO ANY TREATMENT

DATA were given in previous papers[2] on twenty-five males and sixteen non-pregnant females. These can now be supplemented by seven more males and sixteen more non-pregnant females, making thirty-two of each. Of the seven additional males, one survived the removal of the second adrenal for four and one fourth days; one for six and one fourth days; one for seven and one half days; one for eight days and five hours; one for eight and two thirds days; one for fourteen days and eleven hours; and one for fourteen days and twenty hours. The average for the thirty-two males (6.97 days) was only slightly changed.

Of the sixteen additional non-pregnant females, one lived after removal of the second adrenal for three and one half days; one for four days and one hour; one for four days and seven hours; one for four days and eight hours; one for four and two thirds days; one for five days and ten hours; one for six days and ten and one half hours; one for six days and twenty and one half hours; one for seven days and two hours; one for seven days and three and one fourth hours; one for seven days and seven hours; one for nine days and one half hour; one for nine days and two and one half hours; one for ten days and eight hours; one for ten days and eighteen hours; one for eleven and one half days. Average for thirty-two non-pregnant females 6.82 days, practically unaltered.

Our object in preparing so large a series of control animals (which is still being added to) was two-fold: (1) to permit a careful study of the symptoms, blood changes and *post-mortem* appearances (macro- and microscopic) and (2) to permit definite conclusions as to the life-prolonging effect of certain methods of treatment. Further experiments on the influence of intravenous injection of Ringer-dextrose solutions have shown an even greater maximum prolongation of life, into the fifty-fourth day, after loss of the second adrenal in a male dog. Gastric and colonic lavage with hyper- and hypo-tonic NaCl solutions and other liquids were tried systematically in several animals without noticeable effect on the final result. Feeding adrenal preparations and dextrose *per os* was without result; the same was true of intravenous and subcutaneous injection of certain adrenal preparations. Cholin, which some writers have considered a substance of physiological importance associated with the activity of the cortex, was tried in a number of animals in varying doses and had no effect in prolonging life.

Blood studies[3] were made in a large number of animals, embracing estimations of serum proteins, specific gravity, conductivity of blood and serum, relative volume of erythrocytes and serum hemoglobin percentage, counts of erythrocytes and leucocytes, blood sugar, serum calcium, chlorides, non-protein nitrogen, urea, uric acid, creatin and creatinin and amino-acid nitrogen. Concentration of the blood

[1] From the H. K. Cushing Laboratory of Experimental Medicine, Western Reserve University.

[2] Proc. Soc. Exper. Biol. and Med., 1925, xxii, 394; *ibid.*, 1925, xxiii, 190. *Journ. Pharmacol. Exp. Therap.*, Abel Memorial, sent January, 1926.

[3] *Journ. Pharm. Exp. Therap., loc. cit.*

(with decrease in the relative volume of the serum) is very common or perhaps constant towards the end. Frequently the change is extreme. The erythrocyte count and hemoglobin percentage are increased. The conductivity of the blood is diminished. That of the serum was either unchanged or somewhat diminished. This agrees with our result for the chlorine which also remained constant, or sometimes seemed to be moderately lessened. The non-protein and urea nitrogen were markedly increased in the terminal stages. In some cases the increase began definitely before the characteristic symptoms had appeared. (In this connection it may be mentioned that in a case of typical Addison's disease recently studied by one of us (J. M. R.) a high NPN and urea were seen). The amounts of uric acid, creatin, creatinin and amino-acid nitrogen were not materially altered. The undetermined fraction of the NPN sometimes appeared to undergo a significant increase. In some of the cases the serum calcium appeared to be increased. It is only towards the end, when the symptoms have become well established, that any striking diminution in the dextrose takes place. An interesting point is that in a pregnant dog, which remains in good health fifty-five days after removal of the second adrenal, no changes in the blood were observed till three days before death, which occurred on the fifty-ninth day.

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A PRINCIPLE OF CORRESPONDENCE

MERCURY vapor has been bombarded by electrons of homogeneous velocities (produced by magnetic analysis), revealing interesting information on the nature of the probability that an electron will ionize an atom. It has been found that the minimum ionization potential is 10.4 volts, while other critical potentials exist at approximately 10.6, 11.2, 11.6 and 11.9 volts, respectively. Presumably others of higher energies will be noted when the experiments are extended. Further, it has been observed that the probability of ionization is finite when the electron has just enough energy to ionize the mercury atom (10.4 volts) and that this probability decreases with increasing electron energies to the next critical potential, where it takes on a sharp rise to a higher value, decreasing again to the third critical potential, et cetera. The sudden increases of the probability of ionization are attributed to the setting in of various distinct types of atomic energy transitions involving ionization, each type of transition having a maximum probability of excitation for electron energies of the minimum amount able to carry through the process. Thus, the probability of ionization by electron impact resembles in form the radiation quantum absorption probabilities observed in the X-ray region. However, a point of much vital interest is that the probability as a function of the energy is more closely of the form found by Foote, Mohler and Chenault for the probability of ionization of Caesium vapor by light quanta. This fact has suggested the following hypothesis of correspondence in the behavior of electrons and light quanta in atomic processes involving ionization:

Electrons and radiation quanta obey the same general laws, expressed as functions of their energy, concerned with ionization of atoms. In particular, the probability that an electron will produce a given type of ionization expressed as a function of its energy is of the same form as the corresponding probability function for radiation quanta.

This postulate correlates a range of experimental facts that heretofore have been unintelligible. For example, Foote, Mohler and Chenault found a maximum ionization probability in Caesium vapor for light quanta of minimum energy (series limit frequency), which decreased rapidly for light quanta of higher energies, though well below the series limit an anomalously large probability was observed. On the other hand, the writer found that the ionization in potassium vapor increased above the threshold frequency. On the present hypothesis the two sets of experiments are consistent with each other, and the experiments of K. T. Compton and Van Voorhis, Hughes and Klein, and others on the probabilities of ionization by electron impact. Further, it is interesting to point out that the correspondence here suggested is in harmony with the Compton effect. It has been known for a long time that ionization by electrons of large energies (beta rays) may be accounted for along classical lines, *i.e.*, conservation of energy and momentum. The principle here suggested implies, therefore, that there is a type of ionization by radiation quanta of large energy wherein the laws of conservation of energy and momentum are explicitly obeyed. The Compton effect bears out this implication. Using Bohr's theory of ionization by beta rays in conjunction with the above postulate the probability of a quantum ionizing according to the Compton effect may be evaluated and is found to agree well with experimental facts. It is needless to emphasize the utility of the principle in determining ionization probabilities in unknown regions of the radiation spectrum, and finally, it contributes one more condition in statistical theories concerned with the interaction of radiation and matter.

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